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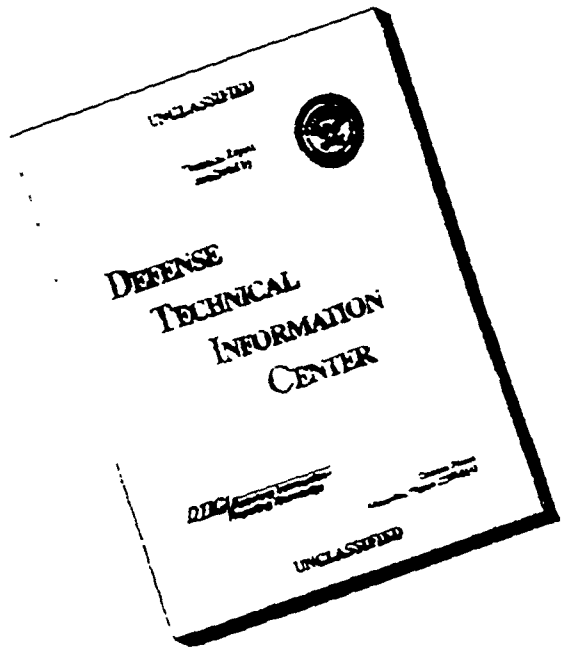

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QUARTERLY REPORT

NNC-Q-2

Contract DAI-19-020-501-ORD-(P)-53

NATIONAL NORTHERN CORPORATION

West Hanover, Massachusetts

DETONATION VELOCITY DETERMINATIONS OF VARIED SYSTEMS AND CONDITIONS

QUARTERLY PROGRESS REPORT 2005-2

Contract DAI-19-020-501-ORD-(P)-58

NINTH QUARTERLY REPORT

NNC-Q-2

June, July, August 1957

Copy No. 107

NATIONAL NORTHERN CORPORATION

West Hanover, Massachusetts

A Subsidiary of American Potash and Chemical Corporation

[redacted]

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NINTH QUARTERLY REPORT

NNC-Q-2

June, July, August 1957

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1.0 INTRODUCTION

This is a Quarterly Report of testing accomplished during the period 10 June 1957 through 9 September 1957 for Picatinny Arsenal under supplemented Contract DAI-19-020-501-ORD-(P)-58 and is designated NNC-Q-2. The first four Quarterly Reports under this contract, NN-Q-1 through NN-Q-4, dealt with free-air blast testing and are summarized in National's Summary Report NN-P-34. The fifth and sixth Quarterly Reports described the work on various RDX systems. This work is summarized in the sixth report for September, October, November 1956, NN-Q-7. The seventh and eighth Quarterly Reports describe preliminary determinations for our current investigation of velocity of detonation in varied explosive systems.

National Northern Corporation gratefully acknowledges the guidance and assistance of Picatinny Arsenal engineers in this investigation.

2.0 OBJECT OF TESTS

The task assigned under this contract, as supplemented, is a survey of varied explosive systems for the purpose of determining any change in detonation velocity with changes in altitude, charge diameter, and degree of confinement.

3.0 CHARGE DATA

3.1 To survey possible changes in behavior of varied explosive systems with changes in altitude, diameter of explosive column and confinement of explosive column, a number of specific conditions have been taken as starting points. In each combination of conditions, five measurements of the detonation velocity of the explosive system will be made.

3.2 The explosive systems included in these tests are TNT, H-6, 70/30 RDX/TNT, 70/30 HMX/TNT and MOX-2B

[redacted]

[redacted]

3.3 These systems are measured at ground, 30,000, 60,000, and 90,000 feet (simulated altitude).

3.4 These systems are tested in cylindrical columns, one and two inches in diameter, eighteen and seven inches long, respectively. These represent our estimates for the maximum explosive weights that can be tolerated in our altitude chamber.

3.5 These explosives, with the exception of MOX-2B, are measured for detonation velocities in two conditions of confinement. In one case, no confinement is used, and in the other, one-quarter-inch-thick steel tubing of appropriate inside diameter MOX-2B will not sustain detonation in unconfined columns of the two selected diameters and an increase in diameter is not considered feasible. To increase diameter would require reduction in length of column to maintain maximum charge weight allowed in our chamber. Columns shorter than those now used would cause our experimental error to be too large.

3.6 Subsequent to initiation of our firing program, we found that we were not able to detonate unconfined TNT completely in the two selected diameters. This is noted in the data tables, following.

4.0 TEST EQUIPMENT

4.1 The measurement of detonation velocity is accomplished by insertion of electrical probes at measured points in the explosive column. These probes, with associated circuits, generate a sharp, high-voltage pulse (rising to approximately 300 volts in 0.1 microsecond). These pulses are used to operate start/stop circuits on an electronic counter-chronograph. The electronic counter-chronograph used is the Potter Model 471 operating at 8 megacycles.

4.2 Tests at simulated altitude are accomplished in our chamber. The chamber has approximate inside dimensions of 12x14x9 feet and may be evacuated

[redacted]

to approximately 120 000 feet 3 mm. Hg.) by a Kinney KD-780 vacuum pump run by a forty horsepower electric motor. These tests run at zero altitude ("ground") were accomplished at our Halifax Testing Range.

5.0 TEST RESULTS

5.1 The tables following include all of the data obtained to date. In these tables, density is determined by dividing the net weight of charge by the calculated volumes of the two sizes-of-charge. The 1"x1" cylinder is calculated to have a volume of 232 cubic centimeters and the 1"x2" cylinder a volume of 360 cubic centimeters.

Altitude (feet)	Average Charge Density (gms/cc)	Measured Segment (meters)	Measured Time (micro-seconds)	Velocity of Detonation (meters/second)
H-6, unconfined, in one-inch diameter column.				
Ground	1.80	.302	41.1	7350
(760-764	1.78	.295	41.1	7180
mm. Hg.)	1.79	303	40.9	7410
	1.81	305	40 9	7460
	1 80	.303	41 1	7370
			Average Velocity	7350
30,000				
(226 mm. Hg.)	1.81	.305	40.4	7550
	1.79	.302	41.3	7310
	1.80	.302	40.9	7380
	1.81	.305	40.9	7460
	1.80	.305	41.6	7330
			Average Velocity	7410
60,000				
(60 mm. Hg.)	1.80	.302	39 3	7680
	1.79	305	40 6	7510
	1 79	302	40 4	7480
	1.80	.303	41 1	7370
	1.79	300	40 5	7410
			Average Velocity	7490

Altitude (feet)	Average Charge Density (gms/cc)	Measured Segment (meters)	Measured Time (micro seconds)	Velocity of Detonation (meters/second)
H-6, unconfined, in one-inch diameter column. (Cont'd)				
90,000	1.78	.302	41.0	7370
(13 mm. Hg.)	1.78	.302	41.0	7370
	1.80	.302	42.1	7170
	1.79	.303	40.6	7460
	1.80	.299	41.4	6980
			Average Velocity	7270
		Average Velocity of 20 tests		7380
H-6, unconfined, in two-inch diameter column.				
Ground	1.83	.099	14.0	7070
(760-764	1.77	.100	14.5	6900
mm. Hg.)	1.84	.102	14.8	6890
	1.75	.102	15.1	6750
	1.81	.100	14.8	6760
			Average Velocity	6870
H-6, confined in $\frac{1}{4}$-inch-thick steel tubing, one inch diameter explosive column.				
Ground	1.72	.305	42.0	7260
(760-764	1.72	.305	42.0	7260
mm. Hg.)	1.72	.303	42.0	7210
H-6, confined in $\frac{1}{4}$-inch-thick steel tubing, two-inch diameter explosive column.				
Ground	1.78	.102	13.9	7340
(760-764	1.78	.102	13.9	7340
mm. Hg.)	1.78	.102	14.4	7080
	1.77	.102	13.6	7500
	1.78	.102	13.7	7450
			Average Velocity	7340

TNT, unconfined, was not sucessfully detonated in either charge-diameter or at any ambient pressure.

TNT, confined in $\frac{1}{4}$ - inch-thick steel tubing, one-inch diameter explosive column.				
Ground	1.55	.305	44.7	6820
(760-764	1.59	.305	44.5	6850
mm. Hg.)	1.61	.303	44.7	6780
	1.60	.304	44.7	6800
	1.62	.305	44.5	6850
			Average Velocity	6820

[illegible] TNT, 70/30, unconfined in one-inch diameter column

Altitude (feet)	Average Charge Density (gms/cc)	Measured Segment (meters)	Measured Time (micro-seconds)	Velocity of Detonation (meters/second)
Ground (760-764 mm. Hg.)	1.79	305	38.1	8010
	1.72	.302	36.1	8370
	1.58	.305	37.6	8110
	1.75	302	38.0	7950
	1.76	303	37.6	8060
			Average Velocity	8100
66,000 (60 mm. Hg.)	1.71	301	37.5	8030
	1.72	.305	37.8	8070
90,000 (13 mm. Hg.)	1.73	305	38.1	8010
	1.71	.305	38.0	8030
	1.62	302	37.9	7970
	1.62	305	38.4	7940
	1.73	302	37.8	7990
			Average Velocity	7990

RDX/TNT, 70/30 confined in 1/4 inch-thick steel tubing one-inch diameter explosive column

Ground (760-764 mm. Hg.)	1.72	305	38.2	7960
	1.74	305	38.5	7920
	1.57	305	39.0	8030
	1.71	.305	38.5	7920
	1.73	.305	38.4	7940
	1.61	305	38.1	8010
	1.62	305	38.0	8030
			Average Velocity	7970
90,000 (13 mm. Hg.)	1.62	306	37.9	8070

6.0 DISCUSSION OF RESULTS

6.1 The table shows detonation velocity determinations for sixty-two samples. In addition to these we have determined that TNT, unconfined, cannot

be completely detonated in one or two-inch diameter columns at ambient pressures of one atmosphere or less. This reduces our program to 320 samples, eliminating MOX-2B and TNT, unconfined, at four altitudes and two diameters of charge.

6.2 We have estimated our experimental error to be $\leq 3\%$, maximum, due to the following probable sources of error:

(a.) Non-uniform density in charges.

(b.) Non-linear velocities over measured segment.

(c.) Precision in measurement of linear distances and elapsed times.

6.3 Density variations within a single column are not readily detected We are proceeding with the testing only after each sample is inspected by X-Ray photography for major flaws. Minor variations in density along the explosive column are not readily detectable.

6.4 Non-linear velocities of detonation occur where steady-state reaction is not established. This is usually corrected by allowing ample "run-up" explosive column ahead of the measured segment. In our experiments, the weight limit imposed by our altitude chamber prohibits ample "run-up" column with the diameters-of-charge specified. This is probably the explanation for the low velocity of detonation obtained with the two-inch diameter, H-6 samples.

6.5 Precision of measurement has been estimated at less than $\leq 1\%$ maximum. Linear distances are precise within one millimeter and time is precise within one-tenth microsecond

6.6 The series completed on H-6, unconfined, in one-inch columns gives the following average velocities:

[redacted]

Ground	:	7350
30,000 feet	:	7410
60,000 feet	:	7490
90,000 feet	:	7270
Average for series	:	7380

The maximum variation, 220 meters per second, is only 3% and within our estimated experimental error.

6.7 Investigations of detonation velocities have been extensively reported by the Naval Ordnance Laboratories. A few of the results reported by Liddiard and Coleburn, NAVORD 2611, and by Donna Price, NAVORD 4510, have been selected for comparison with our results. NAVORD 2611, September 1952, is designated Reference B in the following table. NAVORD 4510, April 1957, is designated Reference A in the following table.

Explosive	Velocity of Detonation (meter/second)	Charge Density (gms/cc)	Charge Diameter (inches)	Confinement (inches of steel)	Source of Data
H-6	7240 (3)	1.72	1.00	.250	NNC
	7380 (20)	1.79	1.00	none	NNC
	7440	1.74	1.625	037	Ref. A.
	7163 (3)	1.659	2.491	none	Ref. B.
TNT	6820 (5)	1.59	1.00	.025	NNC
	6820	1.58	----	----	Ref. A.
RDX/TNT 70/30	7990 (5)	1.69	1.00	none	NNC
	7970 (7)	1.67	1.00	.025	NNC
	8017	1.69	----	----	Ref. A.

7.0 FUTURE WORK

7.1 In general, the experiments will go ahead as planned, with minor changes in technique and the addition of one series of tests.

7.2 Our technique has been modified, for the rest of the program, to include X-Ray examinaton of all samples before they are fired. In this way, we

intend to eliminate samples with flaws and bring about better control of density.

7.3 We intend to add a series of control samples at varied ambient pressures. These samples will be RDX primacord in sufficient length to bring us up to our weight limit. The added length of explosive column and the necessary "run-up" column should provide better than 1% precision for these samples.

8.0 MAN-HOURS

A total of 1313 $\frac{1}{2}$ man-hours has been expended on this contract during this report period.

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